UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

THE EFFECTS OF FACE MASK USE DURING SELF-PACED RUNNING

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Clinical Exercise Physiology

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College of Science and Health
Clinical Exercise Physiology

December, 2021
THE EFFECTS OF FACE MASK USE DURING SELF-PACED RUNNING

By Benjamin D. Ringham

We recommend acceptance of this thesis in partial fulfillment of the candidate’s requirements for the degree of Master of Science in Clinical Exercise Physiology.

The candidate has completed the oral defense of the thesis.

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Thesis accepted

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6/16/2021
ABSTRACT

Ringham, B. The effects of face mask use during self-paced running. MS in Clinical Exercise Physiology, December 2021, 49pp. (C. Foster)

Purpose: This study was conducted to understand the physiological and perceptual effects that face mask use produced during self-paced running.

Methods: Eleven healthy college students performed three randomly sequenced 3200-meter self-paced running trials, each with a different masked condition (no-mask, surgical mask, N95 mask). Heart rate, Rating of Perceived Exertion (RPE), Rating of Perceived Dyspnea (RPD), pace, and completion time were measured for each trial.

Results: The results showed that mask use did not have a significant effect on pace, completion time, or heart rate. Session RPE was significantly higher in the N95 condition compared to control. Both the surgical and N95 conditions had significantly higher dyspnea scores compared to the control.

Conclusion: This study found that during self-paced running, healthy young runners tend to maintain their normally chosen running pace, completion time, and heart rate constant while compensating with higher RPE and dyspnea scores.
ACKNOWLEDGMENTS

I would like to acknowledge Dr. Carl Foster for serving as the chairperson to my thesis and to thank him for the time, energy, wisdom, and mentorship he has invested into myself and my project. I would like to thank Dr. Kim Radtke and Dr. Richard Mikat for their positive feedback and insight. I also wish to thank the subjects that participated in the study, as its completion wouldn’t’ be possible without their involvement. I’d also like to thank my family, professors, and friends, as they have been a constant encouragement as I continue to strive to achieve my personal goals.
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INTRODUCTION

In the midst of the historic coronavirus (SARS-CoV-2) global pandemic (e.g., COVID-19) coaches and self-training athletes have found themselves in an unexpected predicament between conflicting health practice recommendations and the continuation of their training programs. The novel coronavirus’s primary mode of transmission is thought to be through airborne respiratory droplets (Jayaweera et al., 2020). Facemasks effectively block a high percentage of exhaled respiratory droplets from being expelled into the surrounding air and are more effective at preventing infected persons from spreading the virus than directly preventing healthy people from becoming infected. Accordingly, several public health agencies including the CDC have recommended that face coverings should be worn in public spaces to mitigate its spread (Esposito et al., 2020), and many countries have mandated mask wearing as a means to minimize the spread of the virus (Felter & Bussemaker, 2020). As of March 2021, the World Health Organization (WHO) recommended that individuals do not wear masks while exercising as it may limit the ability to breathe (WHO, 2020), yet many fitness centers across the U.S. remain open while requiring facemasks.

Quarantines and restricted access to fitness centers during the COVID-19 era has created unexpected consequences. Individuals are more likely to be sedentary at home and spend excessive amounts of time in sedentary activities which can lead to the development and worsening of chronic diseases (Chen et al., 2020). In addition to
reduction in the risk of cardiovascular-metabolic diseases by exercise (Arem, 2015; Kraus, 2019), it is the general consensus that regular (3-5 days/week) exercise at a moderate training volume (30-60 min) and moderate intensity (60-80% of max capacity) is associated with heightened immune function and a decreased risk of respiratory tract infections (Hull et al., 2020; Nieman et al. 2019). During exercise, breathing frequency and depth increase in order to meet the oxygen demands of the working muscles. This potentially causes more respiratory droplets to be dispersed into the surrounding area and ultimately increases the likelihood that nearby persons will be exposed to an exerciser’s “fume”. Blocken et al. (2020) showed that the potential aerodynamic effect of respiratory droplet transfer is greatest for those following directly behind a runner or cyclist. The use of a facemask could significantly reduce the projection of respiratory droplets (the “fume”), thus limiting spread of viral particles.

The comfort and acceptability of wearing a mask is an important factor which directly impacts exercise tolerance and performance. Active healthcare workers who wore medical masks (either surgical or N95) for an average of 5 hours or more a day reported significantly more headaches, difficulty breathing, and overall mask discomfort (Bakhit et al., 2020). During an incremental exercise test (IET), subjects reported that facemask use lead to severe discomfort during exercise. The factors having the greatest influence on their subjective evaluation were heat, tightness, and breathing resistance (Fikenzer et al., 2020). The temperature and humidity of the environment plays a crucial role of mask acceptance with exercise. Tolerance was primarily determined by the ambient air temperature and humidity, with the acceptance of thermal work conditions decreasing significantly as the ambient temperature and humidity increased (Nielsen et
al., 1987). Studies with an “elevation training mask” (ETM), marketed as an altitude training surrogate demonstrated that the session Rating of Perceived Exertion (sRPE) was significantly higher at matched workloads while wearing a mask than in a non-masked control group (Porcari et al., 2016).

While exercising, the body is continually adjusting to the workload imposed during a training session. Heart rate (HR), blood pressure (BP), and respiratory rate (RR) all progressively increase with incremental exercise (Patel & Zwibel, 2018). Respirator use (such as those worn by fire fighters) during moderate exercise found that there was increased pressure required to inspire and expire through the mask. Consequentially, extra respiratory muscle work was needed to overcome the added resistances (Wilson et al. 1989). Medical mask wear during a IET, resulted in a significant reduction in breathing frequency, tidal volume, and total ventilation. The reduction in ventilation stemmed from corresponding changes with increased inhalation and exhalation time (Fikenzer et al., 2020). Hemodynamic parameters have shown that masked exercise is associated with a higher stroke volume possibly due to prolonged and increased negative intrathoracic pressure (ITP). Epstein et al, (2020) showed that medical masks have a minimal effect on HR, RR, BP, and oxygen saturation during exercise to exhaustion. However, wearing any type of mask (especially N95 masks) increased the end tidal CO₂ (EtCO₂), which could increase the sense of dyspnea.

The pacing pattern performed during a timed or competitive bout of exercise has been thought to follow a self-regulated pace according to the anticipatory-feedback model proposed by Tucker (2009). Specific variations of the pacing strategy used are dependent on the anticipated duration of the event (Ulmer, 1996; Tucker, 2009), the
protocol used, experience with the task (Foster et al., 2009), and the ability to maximize performance while minimizing large homeostatic changes (Foster et al., 1994; Foster et al., 2012). Despite the obvious potential for mask use to modify the feedback received during exercise tasks, to our knowledge, there is no evidence regarding pacing patterns with facemask use in healthy individuals.

Given the substantial increase in mask use, the purpose of this study was to determine the effect of surgical and N95 mask use on spontaneous exercise training intensity in young, relatively fit individuals during their normal exercise routines. It was hypothesized that these subjects would either downregulate their exercise intensity to maintain a comfortable level of breathing and RPE, or that they would accept more breathing discomfort and a higher RPE in order to exercise at the same intensity.
METHODS

Subjects

Eleven healthy college students between 18-25 years of age were recruited for this study. Subjects were required to have previous experience with running. A subjective running history questionnaire was used to confirm whether the potential participants had prior running experience (Appendix D). Eligibility of participants was further assessed using the PAR-Q to screen for cardiovascular and orthopedic conditions that would exclude them from this study. Eligible subjects provided written informed consent before participation in the study. The study protocol (45CFR46) was approved (August 28, 2020) by the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects. The descriptive statistics of the subjects who completed the study are presented in Table 1.

Table 1. Descriptive characteristics of subjects (N=11)

<table>
<thead>
<tr>
<th></th>
<th>Males (mean±SD)</th>
<th>Females (mean±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.3 ± 1.26</td>
<td>23.1 ± 1.07</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>183.5 ± 3.84</td>
<td>165.5 ± 6.46</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.2 ± 12.45</td>
<td>68.4 ± 10.26</td>
</tr>
<tr>
<td>HRmax (bpm)</td>
<td>180.8 ± 7.93</td>
<td>188.3 ± 7.70</td>
</tr>
<tr>
<td>VO$_2$@VT (mL$^{-1}$·kg$^{-1}$·min$^{-1}$)</td>
<td>43.6 ± 9.54</td>
<td>36.5 ± 3.77</td>
</tr>
<tr>
<td>VO$_2$max (mL$^{-1}$·kg$^{-1}$·min$^{-1}$)</td>
<td>52.5 ± 10.40</td>
<td>45.7 ± 6.74</td>
</tr>
</tbody>
</table>
Procedures

Each subject performed a maximal treadmill test (Bruce protocol) to determine the maximal oxygen consumption (VO\(_{2}\text{max}\)), maximal heart rate (HR\(_{\text{max}}\)), and ventilatory threshold (VT). The study was performed as a multiple cross-over, self-controlled trial, with each subject serving as their own control. Subjects performed a non-masked familiarization training session in order to ensure task habituation (Foster et al., 2009) and then three randomly ordered training sessions: (1) no facemask (control); (2) surgical mask; (3) N95 mask. The minimal time interval between tests was 24 hours, and participants were advised to not participate in strenuous exercise during the rest period or exercise the day of a trial.

The trials consisted of a 3200 meter self-paced training run at “their usual training effort”, performed on an indoor track. The subjects were told to run at their “normal workout pace” for each trial. Every 400 meters, HR, RPE, and lap time were recorded. Following the training run, the subject walked another 400 meters as a cool-down. For the purposes of COVID-19 safety, the researchers and participants, masked trials (2, 3) remained masked during the recovery period and during the unmasked trial (1) wore a mask until the trial began and immediately after the cool-down was completed. After the training session, subjects rated their sRPE using the 6-20 modified Borg scale (Borg, 1998), session dyspnea (Hareendran et al., 2012), and the severity of their dyspnea symptoms.

Statistical Analysis

Descriptive statistics were used to analyze measured variables between conditions. One-way ANOVAs with repeated measures (condition by distance) were used
to test for differences in completion time, average running pace, HR, RPE, and session dyspnea between mask conditions. Bonferroni comparisons were used to evaluate pairwise differences in the repeated measure (mask condition) when justified by ANOVA. Alpha was set a 0.05. All data are presented as mean ± standard deviation.
RESULTS

Time to complete the training run was compared between the three different trials. There were no statistically significant differences in run time in relation to mask usage ($p = 0.942$). The average completion time was 16.4 ± 2.16 min (control), 16.5 ± 2.07 min (surgical), and 16.5 ± 2.17 min (N95), as depicted in Figure 1.

![Figure 1. Average 3200 meter completion times](image)

Figures 2 represents the individual running pace for each 400 meters (thin line). The average for each trial is represented by the bold line, and the three different mask condition averages are also compared. The individual pattern of running pace was highly consistent across subjects and mirrored the average running pace for the group. There
was no significant difference in average pace between any of the different conditions (p = 0.746). The average 400m paces were $3.3 \pm 0.06 \text{m} \cdot \text{s}^{-1}$ (control), $3.3 \pm 0.05 \text{m} \cdot \text{s}^{-1}$ (surgical), $3.3 \pm 0.06 \text{m} \cdot \text{s}^{-1}$ (N95) as depicted in Figure 2.

Figure 2. Pace for each trial condition and comparison of averages
Figure 3 represents the average session HR between the three different conditions. There was no significant difference between the conditions (p = 0.716). The session HR average for each condition was 176.9 ± 8.89 bpm (control), 174.9 ± 9.31 bpm (surgical), and 176.3 ± 8.65 bpm (N95).

![Graph showing average running heart rate for Control, Surgical, and N95 conditions.](image)

**Figure 3.** Average running heart rate

Figure 4 represents the individual HR for each 400 meters. The average for each trial is presented by the bolded, black line. The three different mask condition averages are also compared. The %HRmax at the half way point (1600 meters) of each training run was 98.7 ± 0.07% (control), 96.0 ± 0.03% (surgical mask) and 98.0 ± 0.07% (N95 mask).
Figure 4. Heart rate for each trial condition and comparison of averages

Figure 5 represents the individual RPE each 400 meters. The average for each trial is represented by the bold line. The terminal RPE in the N95 condition was significantly higher than the control condition (p = 0.041). There was quite a large
difference in the individual pattern of RPE growth vs distance, but the differences appeared to be individually determined, rather than determined by mask condition.

Figure 5. RPE for each trial condition and comparison of averages
Figure 6 represents the session RPE for the three different trial conditions. Session RPE was significantly higher in the N95 mask condition compared to the control condition (p = 0.003). The average session RPE was 12.8 ± 1.99 (control), 13.6 ± 1.96 (surgical mask), and 14.6 ± 2.21 (N95 mask).

![Graph showing session RPE for each mask condition](image)

Figure 6. Average sRPE for each mask condition
*Significantly greater than control condition (p < 0.05)

Figure 7 represents the session dyspnea scores that were reported after each trial. The rated dyspnea for both the surgical mask and N95 mask trials were significantly higher than the control trial (p < 0.001). The average session dyspnea ratings were 1.4 ± 1.07 for the control, 2.4 ± 1.12 for the surgical mask, and 3.2 ± 1.29 for the N95 mask.
Figure 7. Average dyspnea score for each mask condition
* = significantly greater than control (p < 0.05)
DISCUSSION

During self-paced exercise, the work rate achieved is primarily regulated by feedback from the sensory motor systems based on the presence of a pre-exercise template for that activity and by feedback from the periphery (Tucker, 2009). It is presently thought that the Rating of Perceived Exertion (RPE) is a summation of afferent signals during exercise, and that it, along with central and peripheral fatigue, serve as the “language” of exercise intensity regulation (Azevedo, 2021). With self-paced, masked exercise, it was expected to see either an increase in trial completion time (e.g. decreased pace) or an increase in RPE. The results showed that with masked aerobic exercise at usual training intensities, there was no significant compromise in running time or pace, but rather the subjects accepted a higher RPE in order to maintain the “template” for training performance.

For reference, the U.S. military’s standards for the 2 mile (3218 meters) run range between a minimum and maximum completion time to score points during the army physical fitness test. The standards for men are a maximum of 13 and a minimum of 16.6 minutes, and the standards for women are a maximum of 15.6 and a minimum of 19.6 minutes (Smith, 2021). The average completion time for the current study across trial conditions were 15.3 minutes for men and 17.1 minutes for women. Comparatively, this shows that the study subjects were physically fit, but in combination with their relatively
moderate RPE, it suggests that they could have increased their exercise intensity during the trials.

This study is one of the first to investigate pacing strategies while running with face coverings. Kais (2019) reported that faster, more experienced distance runners kept a more constant running pace throughout the race compared to non-experienced runners. The subjects in this study showed a relatively constant pace across the different masked conditions, suggesting that mask usage did not alter pacing strategies at the runners self-selected exercise intensity. However, we speculate that had the subjects attempted an increased exercise intensity with the masks (e.g. racing conditions), there would have been larger physiological changes, and would have led to a decrease in running velocity.

Epstein et al. (2020), Sinkule et al. (2013) and Smith (2013) found that prolonged usage of an N95 mask was associated with a build-up of CO₂ levels in the body. The buildup of CO₂ leads to increased respiration which shifts the blood to become more acidic (Sinkule et al., 2013). They concluded that individuals with obstructive lung disease should proceed with caution before attempting any type of physical activity while wearing a mask (Epstein et al., 2020; Fikkenzer et al., 2020; Sinkule et al., 2013; Smith et al., 2013). Though our study did not evaluate end-tidal CO₂ levels, the increased end-tidal CO₂ may explain the increased perceived dyspnea scores found in the current study.

The increased perceived breathlessness may also be explained by the findings from Li et al. (2005). In their study, participants perceived the N95 mask to be significantly more uncomfortable than the surgical mask due to the increased breathing resistance, itchiness experienced while wearing the mask, and humidity within the mask. Fikkenzer et al. (2020) also found that the N95 mask was perceived as extremely
uncomfortable compared to the no mask and surgical mask conditions. Factors reported to explain this overall feeling of discomfort included increased breathing resistance, the tight seal of the N95 mask, and increased heat build-up within the mask.

This concept was further supported by a higher rating of perceived dyspnea score (RPD) immediately following the training run in the masked conditions. This observation could have been the result of the relatively low workload. An average running pace of 3.5 m.s⁻¹ would require a VO₂ of about 45 mL.kg⁻¹.min⁻¹, which is only slightly above the recorded value for VO₂@VT (35-43 mL.kg⁻¹.min⁻¹), which normally can be sustained for more than an hour. We hypothesize that higher intensity, masked aerobic exercise would amplify the symptomology of mask wearing and cause a reduction in pace.

Recently, Hagen et al. (2013) demonstrated that the normal upregulation of exercise intensity at training intensities performed in the presence of music was absent when exercise intensity was very high. This suggests that during submaximal exercise, the intensity of exercise is defined by a pre-exercise template, that may be modified when affected by a strong negative-feedback signal. This concept is further supported by the preservation of a time trial starting strategy despite the blinded administration of inspired air with a reduced FiO₂, designed to mimic altitude (Henslin Harris et al. 2013). Future studies should investigate the relationship between higher intensity, masked running, and its effects on trial completion time, RPE, and dyspnea.

When combined with the existing literature, the findings of this study demonstrate that using a mask during self-paced aerobic exercise has minimal effects on HR. Epstein et. al. (2020) showed that during a graded exercise test on a cycle ergometer, mask use had no significant effect on HR, BP, R2, or O₂ saturation. This study utilized submaximal
exercise intensities, and showed no cardiopulmonary alterations while exercising with a
facemask. Typically, HR can be used as a relatively accurate measure of exercise
intensity in normal, unmasked settings. However, this study showed that when running
with a mask HR remains relatively constant as RPE increases suggesting that using HR to
gage exercise intensity while running with a mask may not fully reflect other
physiological factors altered by mask usage.

Most previous literature highlights respiratory discomfort (e.g. dyspnea) as a
primary side-effect of masked exercise. According to the Mayo Clinic (2021), mild to
severe symptoms of masked, exercise-related dyspnea may include; fatigue, dizziness,
headache, significant shortness of breath, muscular weakness, and drowsiness. After
completion of each individual trial, subjects were asked if they experienced any
symptoms of light headedness, dizziness, nausea, or headaches. In the control condition,
there were no symptoms experienced. In the surgical mask condition, 1 subject
experienced mild dizziness. In the N95 condition, 1 one subject reported having a severe
headache immediately following the trial completion, 2 subjects had slight dizziness, and
1 subject had experienced light headedness during the exercise bout. While wearing the
N95 masks, most subjects noted that their perceived breathing effort became noticeably
darker at 1600 meters. This suggests that had the training run been longer, such as
routinely performed by recreational competitors, there may have been a down regulation
of running pace. Nevertheless, our findings demonstrate that, at least up to a distance of
3200-m, self-paced aerobic exercise, can safely be performed by healthy young adults
with either a surgical mask or an N95 mask with little reduction in pace or changes in
physiological markers of exercise intensity.
REFERENCES


APPENDIX A

Borg Rating of Perceived Exertion (RPE) Scale
Borg rating of perceived (RPE) exertion scale from 6-10 (Borg, 1982).

<table>
<thead>
<tr>
<th>Score</th>
<th>Level of exertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion at all</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light</td>
</tr>
<tr>
<td>7.5</td>
<td>Very light</td>
</tr>
<tr>
<td>8</td>
<td>Light</td>
</tr>
<tr>
<td>9</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>10</td>
<td>Hard (heavy)</td>
</tr>
<tr>
<td>11</td>
<td>Very hard</td>
</tr>
<tr>
<td>12</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>13</td>
<td>Maximal exertion</td>
</tr>
</tbody>
</table>

Borg rating of perceived (RPE) exertion scale from 6-10 (Borg, 1982).
APPENDIX B

Borg Modified Rating of Perceived Dyspnea (RPD) Scale
The modified Borg dyspnea scale from 0-10 (Borg, 2010).

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Nothing at all</td>
</tr>
<tr>
<td>0.5</td>
<td>Extremely Slight (just noticeable)</td>
</tr>
<tr>
<td>1</td>
<td>Very Slight</td>
</tr>
<tr>
<td>2</td>
<td>Slight</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Somewhat Severe</td>
</tr>
<tr>
<td>5</td>
<td>Severe</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Very Severe</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Extremely Severe (almost maximal)</td>
</tr>
<tr>
<td>10</td>
<td>Maximal</td>
</tr>
</tbody>
</table>
APPENDIX C

Informed Consent
Informed Consent

Protocol Title: The Effect of Wearing a Mask on Interval Training in Healthy Young Runners

Co-Principal Investigator: Benjamin Ringham
424 9th St. N
La Crosse, WI 54601
507.884.7863

Emergency Contact: Carl Foster
Mitchell Hall 133
La Crosse, WI 54601
608.785.8687

• Purpose & Procedure
  o The purpose of this study is to examine the effects that wearing a surgical mask or an N95 mask have on runners during interval training.
  o 10-15 male and female runners (ages 18-25) who run semi regularly will be recruited.
  o Testing will take place outside on the UW-La Crosse track.
  o Data collection will take place during the month of October (+/- a week). Temperature, wind, and humidity will be recorded during each trial.
  o Each training session the subject will run 2 miles at their “normal workout pace”. HR, RPE, and lap time will be measured each 400m.
  o Subjects will undergo a maximal exercise test, a familiarization trial, and 3 interval training sessions with 3 different mask conditions (1) Control-no mask (2) Surgical mask (3) N95 mask.
  o The order in which subjects will train in for specific condition will be randomized for each individual.

• Potential Risks
  o Subjects may experience typical exercise training side effects such as the feeling of breathlessness, fatigue, sensation of muscle cramping, and overall discomfort.
  o Water will be on scene and provided if requested by the subjects. Researchers trained in first aid, CPR, and AED will be on scene in case of emergency.
In the case of extreme exhaustion, the training session will end and the subject will be closely monitored by researchers until their symptoms return to normal.

The risk of serious or life-threatening complications for healthy runners in this study is close to zero.

• Rights & Confidentiality
  - Participation in this study is completely voluntary.
  - Subjects will be able to withdraw from the study for any reason at anytime with no penalty.
  - Results from this study may be published in scientific literature or presented in professional settings. Data will be coded to protect the identity of the subjects.
  - All information will be kept confidential and will be stored in a locked cabinet on the UW-La Crosse campus.

• Possible Benefits
  - Subjects may experience benefits associated with interval training while participating in this study.

Questions regarding study procedures may be directed to Benjamin Ringham (507-884-7863), the co-principal investigator, or the study advisor Dr. Carl Foster, Department of Exercise and Sport Science, UW-L (608-785-8687). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608-785-8044 or irb@uwlax.edu).

Participant:________________________________________

Date________________

Researcher:________________________________________

Date________________
APPENDIX D

Running History Questionnaire
Running History

1. How many days per week do you typically run? How far and for how long do you typically run?

2. What are your best completion times for the 400m, 800m, 1600m, and 3200m within the last year? (*Answer all that are applicable*)

3. What are your best completion times for the 400m, 800m, 1600m, and 3200m of all time? (*Answer all that are applicable*)
APPENDIX D

Review of Literature
THE EFFECTS OF FACE MASK USE DURING SELF-PACED RUNNING

Introduction

In the midst of the historic coronavirus (SARS-CoV-2) global pandemic, coaches and self-training athletes have found themselves in an unexpected predicament. The virus’s primary mode of transmission is through airborne respiratory droplets, and the Centers for Disease Control (CDC) has recommended that face coverings be worn in public spaces to mitigate its spread (Esposito et al., 2020). Athletes and physically active individuals need to continue their training during the COVID-19 era in order to maintain their fitness level and to prepare for competition. However, the literature and recommendations regarding the effects of mask usage while exercising are relatively lacking. As of August 2020, the World Health Organization (WHO) recommended that individuals do not wear masks while exercising as it may limit the ability to breathe (WHO, 2020). However, as of August 2020, the Director of the Centers for Disease Control and Prevention has recommended universal mask usage as part of an overall strategy to prevent the spread of COVID-19. Most, but not all, states within the United States have mandated mask wearing in all public spaces including gyms, fitness centers, school facilities, and universities. Recent literature has shed some light on the physiological effects of exercising with different types of medical masks, but the research on self-paced running has yet to be examined.
COVID-19 Mitigation of Spread

On March 11, 2020, the WHO officially declared the novel coronavirus (COVID-19) outbreak a global pandemic. The virus has spread quickly and widely with recorded cases being reported in almost every country across the globe. The primary mode of transmission is thought to be through exhaled airborne respiratory droplets (Jayaweera et al., 2020). A major factor enabling COVID-19’s rapid spread is its ability to be transmitted by asymptomatic people (Day, 2020). When measured, the viral load in asymptomatic individuals is very similar to those who are symptomatic (Zou et al., 2020). Pilot studies in various countries have shown that facemask use in public spaces can significantly mitigate the transmission of the virus (Espocito, 2020). Facemasks effectively block exhaled respiratory droplets from being expelled into the surrounding air. Public health agencies have recommended that face coverings be worn in public spaces, and many countries have mandated mask wearing as a means to minimize the spread of the virus (Felter & Bussemaker, 2020).

Exercise Considerations During COVID-19

Quarantining and restricted access to fitness centers during the COVID-19 era has created unexpected consequences. Individuals are more likely to be sedentary at home and spend excessive amounts of time in sedentary activities which can lead to the worsening of chronic diseases (Chen et al., 2020). The mental health and wellbeing of athletes are also a concern during the COVID-19 era. Continuing training is an important component in maintaining both the physical fitness and mental health of the athlete, particularly to reduce the risk of anxiety and depression (Purcell et al., 2019). It is the general consensus that regular exercise at a moderate training volume (3-5 days/week for
30-60 min) at an intensity of (60-80% of max capacity) is associated with heightened
immune function and a decreased risk of respiratory tract infections (Hull et al., 2020).
Elite athletes can continue intense training without an increased risk of illness so long as
there is no sudden increase in training (Nieman & Wentz, 2019).

The literature and recommendations regarding different types of exercise with
facemasks are relatively lacking as there has been no previous need to research the topic.
As of August 2020, the WHO does not recommend that facemasks be worn during
exercise as it may reduce the ability to breathe, yet many gyms require a facemask while
exercising. The dilemma presented is only exacerbated by the unintended consequences
that exercising during the COVID-19 era brings. During exercise, breathing frequency
and depth increase in order to meet the oxygen demands of the working muscles. This
causes more respiratory droplets to be dispersed into the surrounding area and ultimately
increases the likelihood of others nearby to be exposed to a runner’s “fume”. Blocken et
al. (2020) showed that the potential aerodynamic effect of respiratory droplet transfer is
greatest for those following directly behind the runner or cyclist. Depending on a variety
of factors, the “fume” of respiratory droplets around a person may increase from about 2
meters at rest up to 30 meters during cycling at high speeds. The use of a facemask could
significantly reduce the projection of respiratory droplets (the “fume”) and contribute to
limiting the spread of COVID-19.

**Perceived Effects of Exercising with Face Coverings**

The comfort and acceptability of wearing a mask is an important factor which
directly impacts exercise performance. Active healthcare workers who wore medical
masks (either surgical or N95) for an average of 5 hours or more a day reported
significant differences in headaches, difficulty breathing, and overall mask discomfort. The longer the mask was worn the more the perceived discomfort increased (Bakhit et al., 2020). On an incremental exercise test (IET) to exhaustion, subjects reported that facemask use lead to severe discomfort during exercise. The N95 masks was perceived as more uncomfortable than surgical masks, and the factors having the greatest influence on their subjective evaluation were heat, tightness, and breathing resistance (Fikenzer et al., 2020).

The temperature and humidity of the environment and the microenvironment of the mask play a crucial role of mask acceptance with exercise. Acceptance was primarily determined by the ambient air temperature, but it was influenced by the air temperature and humidity inside the mask. Acceptance of thermal work conditions decreased as the ambient temperature increased, and the acceptability of mask conditions significantly decreased with warm humid air (Nielsen et al., 1987).

The session Rating of Perceived Exertion (sRPE) is a reliable and validated method for monitoring individuals training intensity during exercise (Herman et al., 2006; Foster et al., 2021). A study done at UW-La Crosse found that when training with an elevation training mask (ETM) the average sRPE was significantly higher than the control group (Porcari et al., 2016). In contrast, a study done by Epstein et al. (2020) showed that during incremental exercise to exhaustion with medical masks there were no significant differences in RPE compared to the unmasked group. It’s important to note that the two studies used different RPE scales.
Cardiopulmonary Effects of Exercising with Face Coverings

While exercising, the body is continually adjusting to the workload imposed on it during a training session. Heart rate (HR), blood pressure (BP), respiratory rate (RR), and blood lactate (Bla) all increase with intense exercise (Patel & Zwibel, 2019). Studies assessing the pulmonary parameters of exercising with a face covering generally show that there is an increased respiratory effort in comparison to unmasked exercise. A study that used a respirator during moderate exercise to exertion found that there was increased pressure required to inspire and expire air through the mask. Consequentially, extra respiratory muscle work is needed to overcome the added resistances (Wilson et al., 1989). When examining medical mask wear with a maximal exertion test, it was found that there was a significant reduction in breathing frequency and tidal volume. The reduction in ventilation stemmed from corresponding changes with increased inhalation and exhalation time (Fikenzer et al., 2020). Hemodynamic parameters have shown that masked exercise trends towards a higher stroke volume possibly due to prolonged and increased negative intrathoracic pressure (ITP). Epstein et al., (2020) showed that medical masks have a minimal effect on heart rate, respiratory rate, blood pressure, and oxygen saturation during exercise to exhaustion. However, wearing any type of mask (especially N95 masks) increased the end tidal carbon dioxide (EtCO2). The dead space of the mask, added expiratory resistance, and re-breathing of the expired air within the mask all hinder the elimination of CO₂ from the body (Esptein et al., 2020).
REFERENCES


Work while Wearing a Pressure-Demand Respirator. *American Industrial Hygiene Association Journal*, 50(3), 139-146. doi:10.1080/15298668991374426